United States Patent [19]

Sato et al.

[11] **Patent Number: 4,589,828**

[45] **Date of Patent: May 20, 1986**

[54] **ROTATION PREVENTING DEVICE FOR AN ORBITING MEMBER OF A FLUID DISPLACEMENT APPARATUS**

[75] Inventors: **Tadashi Sato; Seiichi Sakamoto; Kiyoshi Terauchi**, all of Gunma, Japan

[73] Assignee: **Sanden Corporation**, Japan

[21] Appl. No.: **521,257**

[22] Filed: **Aug. 8, 1983**

[30] **Foreign Application Priority Data**

Aug. 7, 1982 [JP] Japan 57-137649

[51] **Int. Cl.**^{4} **F01C 1/02**

[52] **U.S. Cl.** **418/55**; 464/103

[58] **Field of Search** 418/55; 464/103, 102

[56] **References Cited**

U.S. PATENT DOCUMENTS

801,182	10/1905	Creux .	
847,069	3/1907	Hawkins .	
916,914	3/1909	Cooley	464/103
1,041,721	10/1912	Ball	418/55
1,884,976	10/1932	Johnson	464/103
1,906,142	4/1933	Ekelhof .	
1,907,447	7/1933	Schlitz .	
2,333,611	11/1943	Wolf	464/103
2,343,244	3/1944	Rose	464/103
3,454,283	7/1969	Benjamin et al.	464/103
3,500,119	3/1970	Price .	
4,160,629	7/1979	Hidden et al. .	
4,259,043	3/1981	Hidden et al. .	
4,303,379	12/1981	Hiraga et al. .	
4,406,600	9/1983	Terauchi et al.	418/55
4,424,010	1/1984	McCullough	418/55
4,468,181	8/1984	Sakamoto	464/103

FOREIGN PATENT DOCUMENTS

17886	6/1934	Australia .	
1960216	6/1971	Fed. Rep. of Germany .	
928465	12/1947	France .	
976187	10/1950	France .	
881409	11/1981	U.S.S.R.	464/103

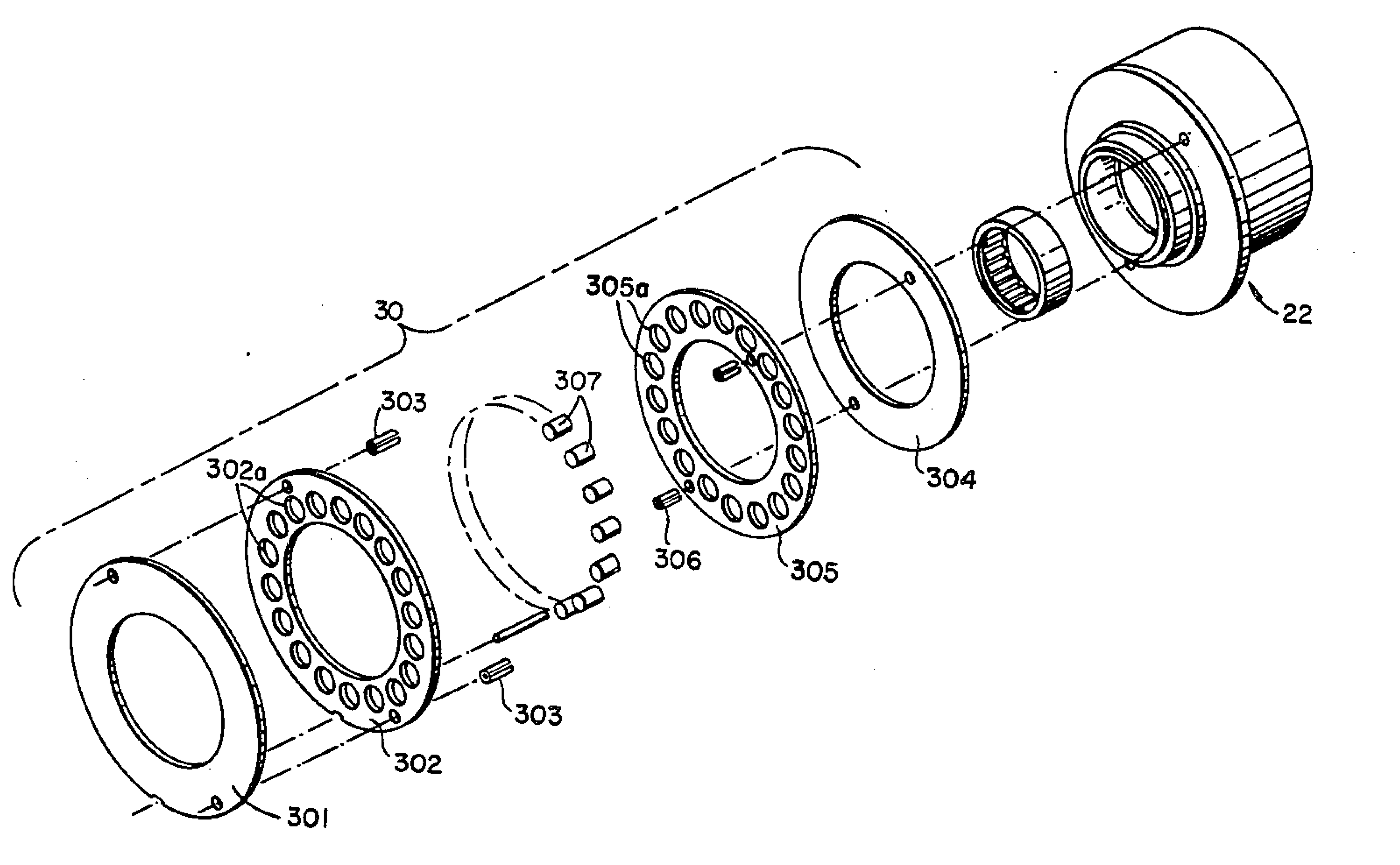
Primary Examiner—Douglas Hart

Attorney, Agent, or Firm—Banner, Birch, McKie & Beckett

[57] **ABSTRACT**

A rotation preventing/thrust bearing device for use in an orbiting piston type fluid displacement apparatus is disclosed. The rotation preventing/thrust bearing device includes a fixed portion, an orbital portion and bearing elements. The bearing elements are cylinder shaped and placed between facing pairs of pockets formed in the fixed and orbital portion. The bearing elements are axially slidable in the pockets. The outer peripheral surface of the bearing elements contacts the opposing inner walls of the pockets, whereby rotation of the orbiting piston is prevented and the axial thrust load from the orbiting piston is carried through cylindrical shaped elements.

7 Claims, 6 Drawing Figures



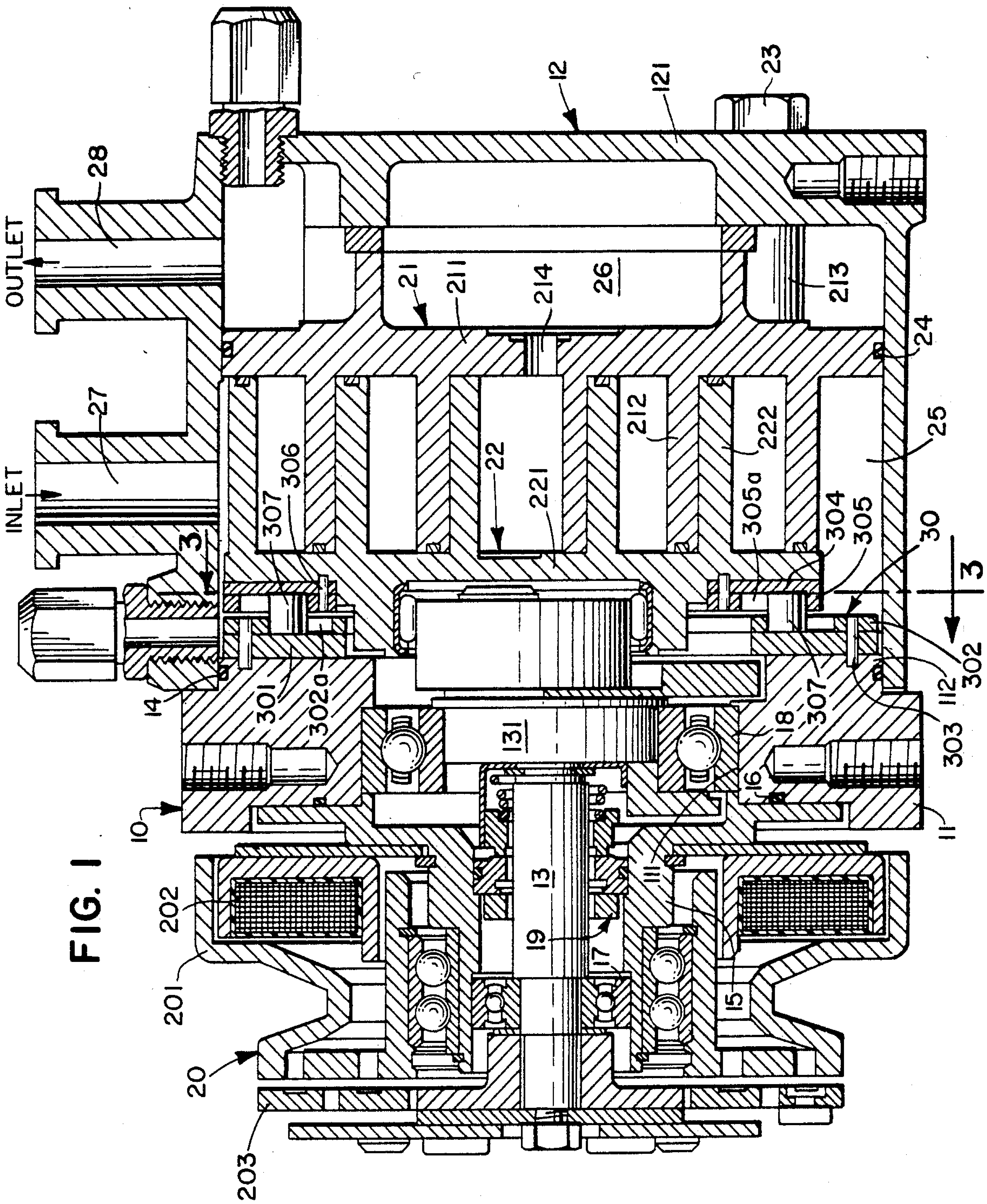

OUTLET
INLET
12
121
23
28
27
21
211
214
26
213
24
22
221
212
222
25
305a
304
305
30
3
306
307
14
301
302a
131
18
16
302
112
303
11
10
13
19
17
111
15
202
201
20
203

FIG. I

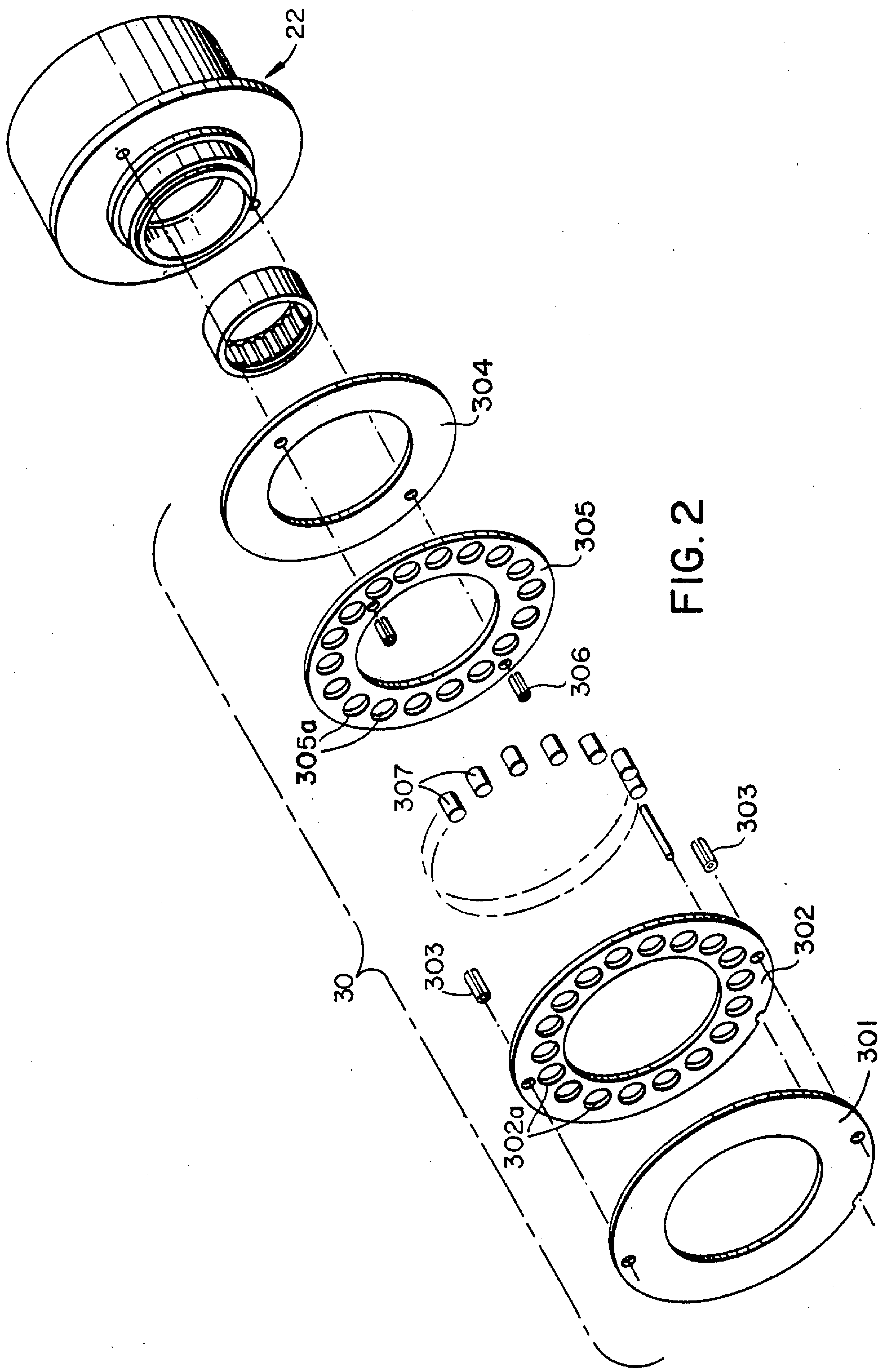


FIG. 2

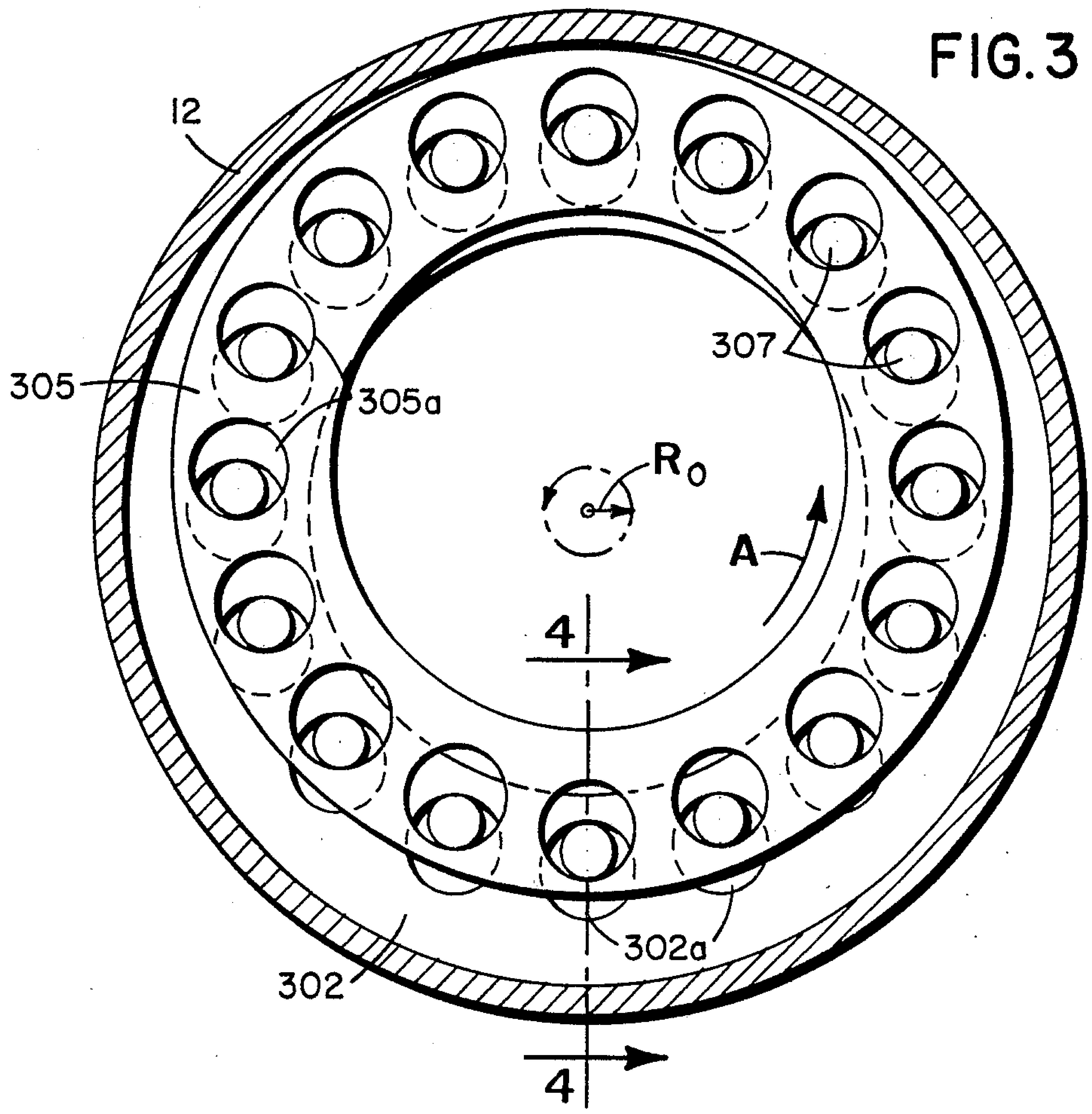


FIG. 3

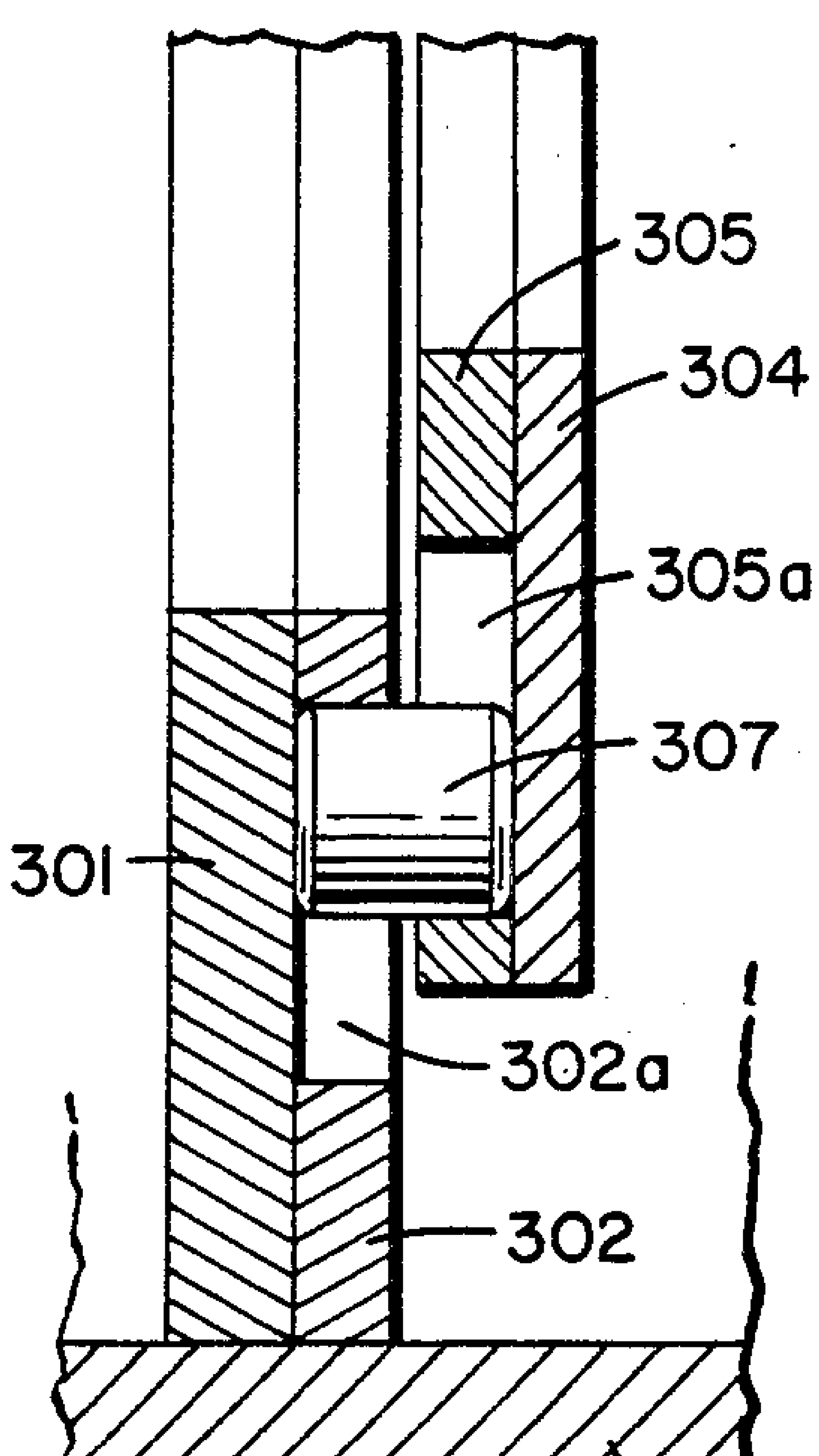


FIG. 4

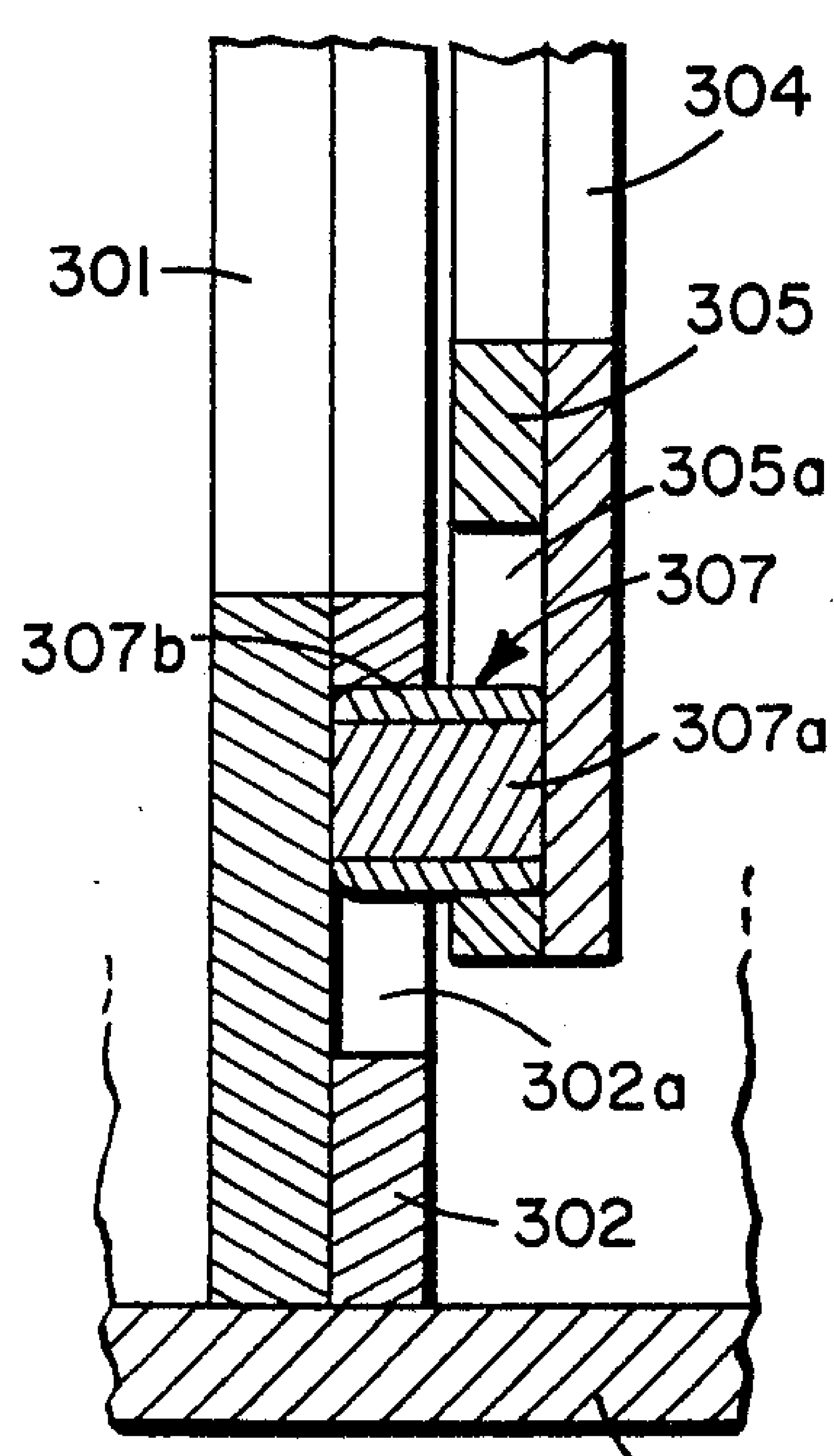


FIG. 5

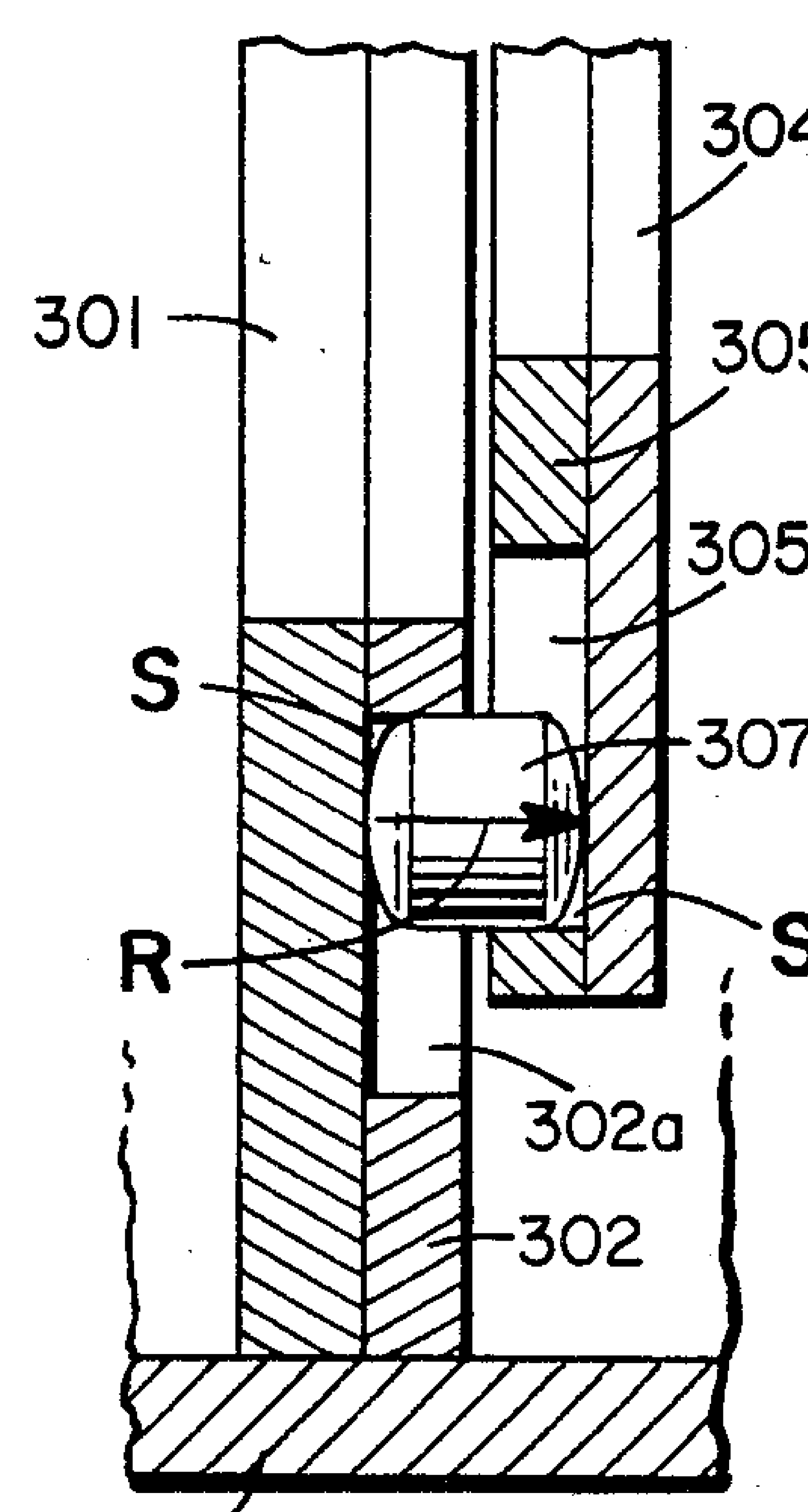


FIG. 6

ROTATION PREVENTING DEVICE FOR AN ORBITING MEMBER OF A FLUID DISPLACEMENT APPARATUS

BACKGROUND OF THE INVENTION

This invention relates to a fluid displacement apparatus, and more particularly, to an improvement in a rotation preventing device for an orbiting member of a fluid displacement apparatus.

There are several types of fluid displacement apparatus which utilize an orbiting member, such as a piston or a scroll driven by a shaft coupled to an end surface of the orbiting member. One such apparatus, disclosed in U.S. Pat. No. 1,906,142 issued to John Ekelof, is a rotary machine provided with an annular, eccentrically movable piston adapted to act within an annular cylinder provided with a radial transverse wall. One end of the cylinder wall is fixedly mounted and the other cylinder wall consists of a cover or disc connected to the annular piston, which is driven by a crank shaft. Other prior art apparatus, which consist of a scroll type fluid displacement apparatus, are shown in U.S. Pat. Nos. 801,182 and 3,500,119. Though the present invention applies to either type of fluid displacement apparatus, i.e., using either an annular piston or a scroll type piston, for purposes of illustration and not limitation the description of the invention will be set in the context of a scroll type compressor.

The above mentioned U.S. Pat. No. 801,183 (Creux) discloses a device including two scrolls each having a circular end plate and a spiroidal or involute spiral element. These scrolls are maintained angularly and radially offset so that both spiral elements interfit to make a plurality of line contacts between their spiral curved surfaces to thereby seal off and define at least one pair of fluid pockets. The relative orbital motion of the two scrolls shifts the line contacts along the spiral curved surfaces and, as a result, the volume of the fluid pockets increases or decreases dependent on the direction of the orbital motion. The scroll type fluid displacement is thus applicable to compress, expand or pump fluids.

Generally, in the conventional scroll type fluid displacement apparatus, one scroll is fixed to a housing of the apparatus and the other scroll, which is the orbiting scroll, is eccentrically supported on a crank pin of a rotating shaft to cause orbital motion. The scroll type apparatus also includes a rotation preventing device which prevents rotation of the orbiting scroll to thereby maintain the scroll in a predetermined angular relationship during operation of the apparatus.

Because the orbiting scroll in conventional scroll type apparatus is supported on the crank pin in a cantilever manner, the orbiting scroll may be subject to an axial slant or tilt. An axial slant occurs also because the movement of the orbiting scroll is not rotary motion, but rather orbiting motion caused by the eccentric movement of a crank pin driven by the rotation of the drive shaft. Several problems result from the occurrence of this axial slant, including improper sealing of line contacts, vibration of the apparatus during operation, and noise caused by physical striking of the spiral elements. One simple and direct solution to these problems is the use of a thrust bearing device for carrying the axial loads. Thus, conventionally, a scroll type fluid displacement apparatus is usually provided with a thrust bearing device within the housing.

One recent attempt to improve the rotation preventing and thrust bearing devices in scroll type fluid displacement apparatus is described in U.S. Pat. Nos. 4,160,629 and 4,259,043 both of which are issued to Hidden et al. The rotation preventing and thrust bearing functions in these U.S. patents are integral with one another. The rotation preventing/thrust bearing device according to these patents comprises one set of indentations formed on the end surface of the circular end plate of the orbiting scroll and a second set of indentations formed on the end surface of the fixed plate attached to the housing. A plurality of balls or spheres are placed between the indentations of both surfaces. All the indentations have the same cross-sectional configuration and the centers of all the indentations formed on both end surfaces are located on circles having the same radius.

In this construction of the rotation preventing/thrust bearing device, during the operation of the apparatus, the balls are held within the indentations by the edge of opposing pairs of indentations. Thus, the rotation of the orbiting scroll is prevented by the balls, while the angular relationship between both scrolls is maintained. Furthermore, during operation each ball is in contact with both end surfaces and rolls along both indentations, so that the axial load from the orbiting scroll, caused by the reaction force of the compressed gas, is carried by one surface through the balls. Since the contact between ball and end surface is formed as a point contact, the pressure acting against the end surface is increased and separation of the end surfaces is likely to occur.

SUMMARY OF THE INVENTION

It is a primary object of this invention to provide an improved rotation preventing/thrust bearing device for an orbiting member of a fluid displacement apparatus.

It is another object of this invention to provide a rotation preventing/thrust bearing device for an orbiting member of a fluid displacement apparatus with improved resistance to wear.

It is a further object of this invention to provide a rotation preventing/thrust bearing device which is simple to make and produce.

A fluid displacement apparatus according to this invention includes a housing. A fixed member is attached to the housing and has a first end plate from which a fixed fluid displacement member extends into the interior of the housing. An orbiting member has a second end plate from which an orbiting fluid displacement member extends. The fixed and orbiting fluid displacement members interfit at a radial offset to make a plurality of line contacts which separate a fluid inlet from a fluid outlet. A driving mechanism, including a drive shaft rotatably supported by the housing, is connected to the orbiting member to effect the orbital motion of the orbiting member. A rotation preventing/thrust bearing device is connected to the orbiting member for preventing the rotation of the orbiting member during orbital motion so that the line contacts between the fixed and orbiting members move toward the discharge side during the orbital motion.

The rotation preventing/thrust bearing device comprises a first ring member fixed on the housing and having a plurality of holes or pockets. A second ring member is fixed on the orbiting member and also has a plurality of corresponding, axially aligned, opposing, holes or pockets. A cylindrical-shaped bearing element is placed in each pair of opposing pockets.

Further objects, features and other aspects of this invention will be understood from the following detailed description of a preferred embodiment of this invention, referring to the annexed drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a vertical sectional view of a compressor unit according to one embodiment of this invention.

FIG. 2 is an exploded perspective view of a rotation preventing/thrust bearing device used in FIG. 1.

FIG. 3 is a sectional view taken along the line III—III in FIG. 1.

FIG. 4 is a sectional view taken along the line 4—4 in FIG. 3.

FIGS. 5 and 6 are a vertical sectional view of a part of a rotation preventing/thrust bearing device according to other embodiments of this invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1, a fluid displacement apparatus in accordance with the present invention is shown in the form of a scroll type refrigerant compressor unit. The compressor unit includes compressor housing **10** having a front end plate **11** and a cup shaped casing **12** which is attached to an end surface of front end plate **11**. An opening **111** is formed in the center of front end plate **11** for the penetration or passage of drive shaft **13**. An annular projection **112**, concentric with opening **111**, is formed on the rear or inside surface of front end plate **11**, and projects towards cup shaped casing **12**. An outer peripheral surface of annular projection **112** contacts an inner wall surface of cup shaped casing **12**. Cup shaped casing **12** is fixed on the inside surface of front end plate **11** by a fastening device, for example, bolts and nuts (not shown), so that the opening of cup shaped casing **12** is covered by front end plate **11**.

Drive shaft **13** is rotatably supported by sleeve **15** through a bearing **17**. Drive shaft **13** has a disk shaped portion **131** at its inner end which is rotatably supported by front end plate **11** through a bearing **18** located within opening **111** of front end plate **11**. A shaft seal assembly **19** is assembled on drive shaft **13** within the shaft seal cavity of sleeve **15**.

An electromagnetic clutch **20**, which comprises a pulley **201**, electromagnetic coil **202**, and an armature plate **203**, is disposed on the outer portion of sleeve **15** to control the transmission of external power to the compressor.

A fixed scroll **21**, an orbiting scroll **22**, a driving mechanism for orbiting scroll **22** and a rotation preventing/thrust bearing device for orbiting scroll **22** are located within an inner chamber of cup shaped casing **12**. The inner chamber is formed between the inner wall of cup shaped casing **12** and front end plate **11**.

Fixed scroll **21** includes a circular end plate **211**, a wrap or spiral element **212** affixed to or extending from one end surface of circular end plate **211** and a plurality of internally threaded bosses **213** axially projecting from the other end surface of circular end plate **211**. An axial end surface of each boss **213** is seated on the inner surface of an end plate **121** of cup shaped casing **12** and fixed by bolts **23**. Circular end plate **211** partitions the inner chamber of cup shaped casing **12** into two chambers, such as a discharge chamber **26** and a suction chamber **25**. A seal ring **24** is located between the outer peripheral surface of end plate **211** and the inner wall of cup shaped casing **12**. A hole or discharge port **214** is formed through circular end plate **211** at a position near the center of spiral element **212**. Discharge port **214** connects the central fluid pocket formed in the center of the interfitting of the spiral elements and discharge chamber **26**.

Orbiting scroll **22** also includes a circular end plate **221** and a wrap or spiral element **222** affixed to or extending from one side surface of circular end plate **221**. Spiral element **222** and spiral element **212** interfit at an angular offset and a predetermined radial offset. At least a pair of sealed off fluid pockets are thereby defined between both spiral elements **212**, **222**. Orbiting scroll **22**, which is connected to the driving mechanism and to the rotation preventing/thrust bearing device, is driven in an orbital motion at a circular radius by rotation of drive shaft **13** to thereby compress fluid passing through the compressor unit, according to the general principles described above. Generally, the radius of orbital motion is given by the following formula:

$$R_o = (\text{pitch of spiral element}) - 2(\text{wall thickness of spiral element})/2$$

The pitch of spiral element can be defined by 2 rg, where rg is the involute generating circle radius. The radius of orbital motion R_o is also illustrated as the locus of an arbitrary point on orbiting scroll **22**. The spiral element **22** is radially offset from spiral element **212** of fixed scroll **21** by the distance R_o. Thus, orbiting scroll **22** undergoes orbital motion of a radius R_o upon rotation of drive shaft **13**.

As the orbiting scroll **22** orbits, the line contacts between spiral elements **212**, **222** move toward the center along the spiral curved surfaces of spiral elements **212**, **222**. The fluid pockets defined by spiral elements **212**, **222** also moved towards the center with a consequent reduction of their volume and thus a compression of the fluid in the fluid pockets. Fluid or refrigerant gas, introduced into suction chamber **25** from an external fluid circuit through inlet port **27** formed on cup shaped casing **12**, is drawn into the fluid pockets formed between spiral elements **212**, **222**. Following the orbital motion of orbiting scroll **22**, the fluid in the fluid pockets is compressed and subsequently discharged into discharge chamber **25** from the central fluid pocket of the spiral elements through hole **214**. The fluid is then discharged to the external fluid circuit through outlet port **28** formed in cup shaped casing **12**.

Referring to FIGS. **2**, **3** and **4**, rotation preventing/thrust bearing device **30** will be described. Rotation preventing/thrust bearing device **30** includes a fixed portion, an orbiting portion, and bearings.

The fixed portion includes a fixed annular race **301** and a fixed ring **302** formed separately from fixed race **301**. Annular fixed race **301** is placed within an annular groove formed on the axial end surface of annular projection **112** of front end plate. Fixed ring **302** is fitted against an axial end surface of fixed race **301**. Race **301** and ring **302** are fixed on the end surface of annular projection **112** by pins **303**.

The orbiting portion includes an annular orbital race **304** and an orbital ring **305** formed separately from orbital race **304**. Orbital race **304** is placed within an annular groove formed on the end surface of circular plate **221** of orbiting scroll **22**. Orbital ring **305** is fitted against an axial end surface of orbital race **304**. Race **304** and ring **305** are fixed on the end surface of circular plate **221** by pins **306**.

Fixed ring **302** and orbital ring **305** face each other with a predetermined clearance and each have a plurality of axially aligned, corresponding holes or pockets **302***a* and **305***a*, respectively. The radius of each of the pockets **302***a* of fixed ring **302** is the same as the radius of each of the pockets **305***a* of orbital ring **305**. Pockets **302***a* of fixed ring **302** correspond in location to pockets **305***a* of orbital ring **305**. The center of each pair of pockets **302***a*, **305***a* are radially offset by an amount equal to the distance R_o. Bearings, such as cylindrical shaped elements **307**, are placed between the facing pairs of pockets **302***a*, **305***a*.

Referring to FIG. **3**, the operation of the rotation preventing/thrust bearing device will be described. In FIG. **3**, the center of orbital ring **305** is shown at its upper position and the direction of rotation of the drive shaft is counterclockwise, as indicated by arrow A. When orbiting scroll **22** is driven by the rotation of the drive shaft, the center of orbital ring **305** orbits about a circle of radius R_o (together with orbiting scroll **22**). However, a moment is caused by the offset of the acting point of the reaction force of the compression and the acting point of the drive force acting on orbiting scroll **22**. This reaction force tends to rotate orbiting scroll **22** in a counterclockwise direction about the center of orbital ring **305**. But, as shown in FIG. **3**, the cylindrical shaped elements **307** are placed between the corresponding pockets **302***a*, **305***a* of rings **302** and **305**. In the position shown in FIG. **3**, the contact of the elements **307** at the right side of the rotation preventing/thrust bearing device with the walls of fixed pockets **302***a* prevents the rotation of orbiting scroll **22**; the cylindrical shaped elements **307** on the left side of the device, do not contact the walls of fixed pockets **302***a* and thus, in the position shown in FIG. **3**, do not serve to prevent rotation of rings **305** and race **304**. In any given position of orbiting scroll **22**, it will be appreciated that only half the cylindrical shaped elements **307** function to prevent the rotation of orbiting scroll **22**. However, all the cylindrical shaped elements **307** support the axial thrust load from orbiting scroll **22**. The axial end surfaces of cylindrical shaped elements **307** face, and slidably contact, fixed and orbiting races **301**, **304**. This axial thrust load is transmitted to fixed race **301** through cylindrical shaped elements **307**.

In this construction of rotation preventing/thrust bearing device **30**, fixed race **301** and orbital race **304** are preferably formed of aluminum alloy, a soft metal, and both rings **302**, **305** and cylindrical shaped elements **307** are preferably formed of a hard metal, such as steel. Therefore, the wear resistance and fit of the interface of the sliding surfaces of cylindrical shaped elements **307** and races **301**, **304** is improved because of the hard metal to soft metal sliding contact. Alternatively, races **301** and **304** can be made of hard metal and cylindrical shaped elements **307** can be made of soft metal. Furthermore, the rotation preventing force is received by a hard metal in the preferred embodiment. The breakage of the pockets, which may occur if the rings **302**, **305** and cylindrical shaped elements are formed of the soft metal, will also be prevented. Furthermore, if the wear surfaces of elements **307** and rings **302**, **305** are treated to further improve their wear resistance, the compressor may be operated without additional lubrication.

As shown in FIG. **5**, cylindrical shaped element **307** may be formed of a soft metal body **307***a*, such as an aluminum alloy, with its longitudinal, cylindrical wear surface covered by a cylindrical bushing of hard metal, as shown at **307***b*.

An alternative construction for elements **307** is shown in FIG. **6**. The axial end surfaces of cylindrical shaped element **307** are formed with a small curvature, of radius R. In this construction, a wedge shaped space S is defined between the end surface of race **301**, **304** and the axial end surface of cylindrical shaped element **307**. During the operation of the compressor, oil which is contained in the compressor penetrates into space S and develops a thrust oil pressure. This oil pressure supports the thrust load from orbiting scroll **22** without contact between the race and the cylindrical shaped element.

This invention has been described in detail in connection with preferred embodiments. However, this description is for purposes of illustration only. It will be understood by those skilled in the art that other variations and modifications can be easily made within the scope of this invention which is limited only by the following claims.

What is claimed is:

1. In an orbiting member fluid displacement apparatus including a housing, a fixed member attached to said housing and having a first end plate from which a fixed fluid displacement member extends into the interior of the housing, an orbiting member having a second end plate from which an orbiting fluid displacement member extends, said fixed and orbiting fluid displacement members interfitting at a radial offset to make a line contact separating a fluid inlet from fluid outlet, and a driving mechanism connected to said orbiting member to drive said orbiting member in an orbital motion at a predetermined orbital radius, and rotation preventing/thrust bearing means connected to said orbiting member for preventing rotation of said orbiting member and for carrying axial thrust load from said orbiting member during orbital motion, the improvement wherein said rotation preventing/thrust bearing means comprises:

an orbital body fixed to said orbiting fluid displacement member;

a fixed body fixed to said housing, said fixed body facing said orbital body at a predetermined clearance;

said fixed and orbital bodies each having a plurality of axially aligned, radially offset opposing pockets; and

a cylindrical shaped bearing element carried within each pair of said opposing pockets, with one of the axial end surfaces of said bearing elements in sliding contact with an orbital race of said orbital body, the other axial end surface of said bearing elements in sliding contact with a fixed race of said fixed body, and the outer cylindrical bearing surface of at least some of said bearing elements engaging the walls of said pockets in said fixed body so that the engagement of said bearing elements with the walls of said pockets prevents rotation of said orbiting member and the axial end surfaces of said bearing elements carry the axial thrust load from said orbiting member to said fixed member.

2. In a scroll type fluid displacement apparatus including a housing, a fixed scroll fixedly disposed relative to said housing and having a first end plate from which a first wrap extends into the interior of said housing, an orbiting scroll having a second end plate from which a second wrap entends, said first and second wraps interfitting at an angular and radial offset to make a plurality of line contacts to define at least one pair of sealed off fluid pockets, a driving mechanism operatively connected to said orbiting scroll to effect the orbital motion, and rotation preventing/thrust bearing means connected to said orbiting scroll for preventing the rotation of said orbiting scroll during orbital motion, the improvement wherein said rotation preventing/-thrust bearing means comprises:

an orbital annular race fixed on said second end plate of said orbiting scroll and an orbital annular ring fitted to an axial end surface of said orbital annular race;

a fixed annular race fixed on said housing and a fixed annular ring fitted to an axial end surface of said fixed annular race;

said fixed annular ring facing said orbital annular ring at a predetermined clearance and said orbital annular ring and said fixed annular ring each having a plurality of axially aligned, radially offset opposing pockets; and

a cylindrical shaped bearing element carried within each pair of said opposing pockets with one of the axial end surfaces of said bearing elements in sliding contact with said orbital annular race, the other axial end surfaces of said bearing elements in sliding contact with said fixed annular race, and the outer cylindrical bearing surface of at least some of said bearing elements engaging the walls of said pockets in said fixed body so that the outer cylindrical bearing surface of said bearing elements prevents rotation of said orbiting scroll and the axial end surfaces of said bearing elements carries the axial thrust load from said orbiting scroll to said fixed member.

3. The scroll type fluid displacement apparatus of claim 2 wherein said orbital annular race is formed of soft metal, said fixed annular race is formed of soft metal and said bearing elements are formed of a hard metal.

4. The scroll type fluid displacement apparatus of claim 2 wherein said orbital and said fixed annular races are formed of a hard metal and said bearing elements are formed of a soft metal.

5. The scroll type fluid displacement apparatus of claim 2 wherein said bearing elements comprise a soft metal core portion and a hard metal cylindrical bushing surrounds the longitudinal, cylindrical wear surface of said core portion.

6. The scroll type fluid displacement apparatus of claim 2 wherein an axial end surface of said bearing elements is curved so that a space is formed between the axial end surface of said bearing elements and said fixed and orbital races, thus permitting oil to penetrate said spaces and develop a thrust oil pressure.

7. The scroll type fluid displacement apparatus of claim 2 wherein the axial end surfaces of said bearing elements are in sliding contact with said fixed and orbital annular races.

* * * * *